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SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM

Cleanroom Engineering Handbook
Volume 3
Project Execution in the Cleanroom Environment

Contract No. F19628-88-D-0032
Task ID52 – STARS Technology Transfer Demonstration Project for the U.S. Army

Prepared for:

Electronic Systems Center
Air Force Materiel Command, USAF
Hanscom AFB, MA 01731-2816

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This is one of a series of six engineering handbooks prepared for and used by the engineering staff at Picatinny Arsenal for the STARS technology transfer demonstration. The handbooks define the engineering process and algorithms that will be used in Cleanroom projects. They are designed to provide support to trained engineers using Cleanroom Engineering, not to substitute for training.

This handbook, Volume 3, provides managers and team leaders with guidance in the planning, directing, and controlling of Cleanroom projects. Project execution is the planning for, and the controlling of the solution to the four major decisions within a software project. These decisions are:

1. To assign tasks to specific team members in the execution of the project
2. To determine the expected completion date for some phase of the project
3. To determine if the progress made toward developing the desired software and the resources consumed to date are in balance with each other and with the project's Business Plan.
4. To determine if some aspect of the design is acceptable and the design effort should continue in the current direction or if the direction should be altered. If the direction is to be altered then a replanning effort must be initiated.

This volume covers topics such as completion conditions, metrics collection, forms driven process management system, file and tool reference table, and an automated process management system named CEPA (Cleanroom Engineering Process Assistant).

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PREFACE

This series of handbooks is prepared for use by managers and engineers assigned to Cleanroom projects at Picatinny Life Cycle Software Engineering Center.

These handbooks define the engineering process and algorithms that will be used in Cleanroom projects.

This document was developed by the IBM Federal Systems Company, located at 800 North Frederick Avenue, Gaithersburg, MD 20879 and Software Engineering Technology, Inc. located at 2770 Indian River Boulevard, Vero Beach, FL 32960. Questions or comments should be directed to Mr. Paul Arnold at 301-240-7464 (Internet: pga@sei.cmu.edu).

CLEANROOM ENGINEERING PROJECT EXECUTION

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CLEANROOM ENGINEERING PROJECT EXECUTION

SECTION 1: INTRODUCTION

The purpose of this handbook is to provide managers and team leaders with guidance in the planning, directing and controlling of Cleanroom projects. This class of decisions are called Project Execution decisions. In volume 2, Project Execution was defined as:

> Project Execution is the planning for, direction of, and controlling of the solution to the four major decisions within a software project. These decisions are:
> 1) To assign tasks to specific team members in the execution of the project.
> 2) To determine the expected completion date for some phase of a project.
> 3) To determine if the progress made toward developing the desired software and the resources consumed to date are in balance with each other and with the project's Business Plan.
> 4) To determine if some aspect of the design is acceptable and the design effort should continue in the current direction or if the direction should be altered. If the direction is to be altered then a replanning effort must be initiated.

Project execution decisions are made by team leaders and the software engineering manager for a specified project in the case of the first three decisions. In the case of last decision higher levels of management may be involved depending on the financial stakes associated with the decision.

1.1 Project Execution Decisions

There are four main classes of decisions that team leaders and the software engineering manager need to make while executing a project. Each of these classes are briefly described in this section.

1. To assign tasks to specific team members in the execution of the project.

This decision is made over and over again as the project progresses. This decision is the dispatching decision. The dispatching decision requires current knowledge of the project status and resource availability. Dispatching decisions directly impact realization loss. The term realization loss is applied to the concept that effort is wasted when ever a person works on a task or attempts to work on a task and subsequently determines that some part of the prerequisite input information was not yet complete, correct or a the wrong version was accessed. Therefore, when making the dispatching decision it is very important to not release work the work until all inputs are available. Every time a task is released for execution and all prerequisite work is not complete and verified as correct then the work will result in wasted effort or realization loss. In typical engineering environments realization loss is a major source of reduced productivity.

Typically, no planning document is prepared to justify a dispatching decision. Dispatching decisions are normally made verbally or with a memo or there may be an assignment form issued. The team leader may prepare a line and page schedule (Gantt Chart) for the tasks of immediate concern in order to support dispatching decisions. This schedule is not published. It is prepared to help reach a personal decision.

In Cleanroom, when using CEPA to support dispatching, the resource assignment is made by the team leader by filling in a screen and the dispatching decision is automatically made when all preconditions are fulfilled according to the Cleanroom process definition. When this happens, the task is put on the engineers pick list. In a manual situation, the same process must be implemented with a manual procedure.

Dispatching in the Cleanroom environment is discussed in section 2.

2. To determine the expected completion date for some phase of a project.

This decision is to support a control decision. As projects unfold, the progress may be slower or faster than anticipated. Therefore, at frequent intervals, managers are required to re-estimate the expected completion date for major project milestones. Such re-estimates either trigger the need for a replanning effort or they confirm the current schedule.

Typically estimates of completion dates for milestones are contained in a status report or some other review document.

Normally, a manager will need to prepare a model to determine estimated completion dates. In some cases, the manager or team leader will want to develop a Gantt chart or network model. This can be done using any of the standard Project Management packages. All such packages permit the model to be displayed in either form and many permit the model to be entered in either form. The important issue is that the model must not be so detailed as to lose perspective or so gross as to have no meaning. When preparing any model to estimate time the naming conventions used in the project process model defined in the Software Development Plan (SDP) should be used to construct the model. It is necessary that there be complete traceability.

In making forward projections, it is important that the variability that can occur in the project be included in the model. Traditional methods do not do this. As discussed above in point 1, models of software development projects should not assume a waterfall model. An accurate process model of software development has quite a complex control structure and any particular project can take quite complex paths through the control structure. Therefore, a model that permits management to evaluate the expected duration and variance should be used. Today, among software projects, it is the exception to use such models.

Developing estimates of project completion are discussed in Section 4 of volume 2.

3. To determine if the progress made toward developing the desired software and the resources consumed to date are in balance with each other and with the project's Business Plan.

The basic task to making this decision is to make the right measurements. The purpose of these measurements is to support a replanning decision based on project performance. These same measurements support the dispatching decision.

The actual work effort performed by each engineer on each task needs to be collected. CEPA can be developed to routinely collect all the required measures.

There are two basic types of measures. Effort measures are where time spent by engineer working on a task is collected. Progress measures are where the material contained in the state data repository is analyzed to determine how many of various documents are complete and the extent of the design hierarchy is compared to current projected size of the design hierarchy.

A formal planning document is not normally prepared to support the decision that replanning is required. Managers look at the measurements as they are summarized as the project progresses and they make a judgement to initiate a replanning effort based on their accumulated wisdom.

Metrics collection is discussed in section 3 of this handbook.

4. To determine if some aspect of the design is acceptable and the design effort should continue in the current direction or if the direction should be altered. If the direction is to be altered then a replanning effort must be initiated.

In making these decisions, the manager is called upon to use his/her engineering judgment to make what are typically very difficult decisions that have a great influence on the successful outcome of a project and its eventual cost. In all cases, there is some difficulty with the current state of the design. When such suspensions arise there are two basic courses of action. One is to continue on the current course and see if the everything in fact works out acceptably. If it does, that is the right decision because the desired result was obtained at the lowest cost. On the other hand, if at some later stage the situation becomes impossible, the cost of rework is greater, or it may even be so high that it becomes necessary to scrap the project. In this case, the wrong decision was made. It is also possible that a project can be stopped to consider the need for rework and none is required. In that case, another bad decision was made. Frequently, these decisions are very close decisions so they are quite difficult to make. Typically, it takes experience to build up a base on which to make such decisions.

In the generic process model presented in volume 1, there were four processes defined where such decisions need to be considered. The four processes are:

proc P4.i.1: Prepare Plan for Cycle i
do [P4.i.1: Prepare Plan for Cycle i]
con
M4.i.1.1: Establish Objectives For Cycle i;
M4.i.1.2: Allocate Time Period To Cycle i;
M4.i.1.3: Prepare Plan For Cycle i;
noc;
until
Completion Conditions achieved for M4.i.1.1, M4.i.1.2 and M4.i.1.3
od;
corp;

and

proc P4.i.5: Appraise Cycle i Specifications
do [P4.i.5: Appraise Cycle i Specifications]
M4.i.5.1: Review and Evaluate Cycle i specifications;
M4.i.5.2: Management Decision: (1) Specifications Suitable To Initiate Development or (2) Specification Problems-Replan Project or (3) Continue Specification Effort with cycle i+1;
until
Completion Conditions achieved for M4.i.5.2
od;
corp;

The following two tasks have to with providing intellectual leadership through the provision of engineering judgement in two critical areas.

```
proc PCS2: Update Specifications
    [This process results in an updated specification]
    do [PCS2: Update Specification]
        if Question or Issue or stimulus from outside project or error discovery causes a
           specification change
        then
            do
                con
                    SCS2.1: Increase Understanding of Problem and Solution Domains;
                    SCS2.2: Update Specification;
                noc;
                SCS2.3: Publish Change Sheets;
                MCS2.4: Management Decision: (1) OK continue current plan with revised
                        specifications or (2) Revised specifications require replanning
            until
                Completion Conditions for MCS2.4 achieved
            od;
        fi;
    od;
corp;
```

In the above process, the situation is that for some reason the previously thought to be complete specifications have to be changed. The question is: Can the teams continue under the current plan or is it best to initiate a replanning activity to evaluate the economic impact of the change?

In the following process, the situation is that during the certification process for an accumulation it has been found that the software is not up to standard. The question is what is the best action to take: Continue testing and fixing or reject the increment(s) and restart design. In either case is it necessary to start a replanning activity since the project plan is no longer accurate.

proc P6.j: Software Certification for Increment j
[P6.j certifies the code, and makes the decision as to whether an increment will be accepted or rejected.]
do [P6.j: Software Certification for Increment j]
C6.j.1: Build Accumulation j;
if no pre-certification failures
then
while
certification plan requires more tests **and** sufficient failures have not been observed to make it desirable to terminate testing and wait for corrections
do
C6.j.2: Perform Certification Tests for Accumulation j;
od;
fi;
if at least one failure observed **and** observed failures are considered to be correctable
then
C6.j.3: Prepare failure report(s);
D6.j.4: Correct failure, verify correction and prepare ECN;
fi;
M6.j.5: Management Decision: (1) certification complete-accumulation quality satisfactory, (2) certification complete-quality not satisfactory-replanning Is required or (3) certification should continue;
if not Management Decision is certification should continue
then
C6.j.6: Prepare Certification Report;
fi;
until
Completion Conditions achieved for C6.j.6
od;
corp;

It is not feasible to provide any general guidance on how managers should go about making these decisions. Each project situation and the associated risks will be different. In each case the manager must make a decision that reaches the proper balance between risk and reward.

1.2 Completion Conditions

All engineering activities in the process model are

do

...

until

...

od;

process structures. The until condition are called Completion Conditions. They are a series of questions that can be answered with a yes or no. The task is considered complete when all questions can be answered with a yes. In the Cleanroom process, all Completions Conditions must be answered with a yes by all members of the team that is responsible for the task. When this occurs the activity is marked as complete thus authorizing subsequent activities to be initiated.

The Completion Conditions, while all viewed as objective (yes/no) decisions, have a variety of manifestations. Some of the tasks have Completion Conditions that are forms with some number of questions. With some concurrent tasks, the Completion Conditions for the concurrent activities are combined. In other cases, the Completion Conditions are based on control flow conditions of the Cleanroom process presented in Volume 1.

The Completion Conditions for each product have been recorded on forms. There is one form for each engineering activity. Hard copies of these forms are included in section 4 of this handbook and soft copies are available to facilitate their use in managing and controlling projects.

CLEANROOM ENGINEERING PROJECT EXECUTION

SECTION 2: DISPATCHING

In the Cleanroom environment, projects are process driven. That means the dispatching decisions are made by using the process definition for the project. The generic process definition is contained in the Software Development Plan. The process definition can be thought of as a program that is executed by the managers and the team leaders. In one software project, there will be one active process definition for each major item of software. In 2167A language, this means one active process for each Computer Software Configuration Item (CSCI).

Each active process definition should be regarded as a separate sub-project. The parameters that describe the project may change during the project as a result of replanning decisions and findings about the program structure. These changes will manifest themselves in changes to parameters that control loops. Typical examples are the number of specification cycles and the number of increments.

The project control structure is defined by the process and the results of work will cause different branchings to occur. There are millions of possible paths through the control structure. As the project progresses the managers must keep track of where they are in the process and make their next dispatching decision(s).

Projects are executed by assigning responsibility for performing a process or an activity to a team or an engineer. The control flow among processes and activities is specified in terms of sequential, alternative, iterative and concurrent operations. Therefore, the next process or activity to be assigned depends on the realizations of prior processes and/or activities as defined by the control structure.

Process assignments are triggered by the occurrence of a project event. Project events occur whenever a team or person that is responsible for a process or activity reports that an activity is complete or some result has occurred according to the evaluation of some predicate in the control structure that defines the project process. Each time a project event occurs, it is necessary for a manager or team leader to make a dispatching decision followed by assignment of responsibility to some team or person for the next activity or process to be invoked. The dispatching decision may also require the suspension of some currently assigned processes and/or activities.

A process definition, in addition to the control flow, must define the data flow among activities. The process needs to define the data (documents) that flows into the activity being dispatched from predecessor activities and the data (documents) that is to flow from the activity when the activity is complete. **In the Cleanroom environment, all data or document files are maintained in the State Data Repository.** This makes the definition of data flow quite easy because the all data flows to and from one place. The names of the State Data Repository files

associated with each process are collected in a table for easy reference in the Section 5 of this handbook.

The integrity of the state data repository must be maintained through continuous, rigorous configuration management. Frequently parts of the state data repository will be printed out and the resulting documents used to support work, reviews, etc. These documents are not to be considered the official copy. The only official copy is the soft copies in the state data repository.

In addition to the control flow and data flow, it is necessary to define the tools that will be used to support each of the processes. The required tools for each process are again defined in a table included in Section 5 of this handbook.

To maintain the project in intellectual control the managers need to manage the project to the process definition. That means they need to understand the process and know where they are in the process at all times. This can be done in several ways.

Manual - Informal In this case, the managers understand the process so well that they can keep track of the process and progress in executing the process in their head, perhaps consulting generic process for guidance when needed. This seems to work quite well for small projects that are being performed by well trained teams.

Manual - Forms Based In this case, the process as defined for each project is recorded on a series of forms. Progress, branching decisions, dates and current assignments are recorded on the form. The form is used to support the making of dispatching decisions, recording progress and reporting on status. These forms can either be maintained in hard or soft copy formats. Forms are maintained current with progress with executing the process. The details of a forms driven system are discussed in section 2.1. This is the type of Process Management System that will be defined for the COFT project.

Automated In this case, the process is defined to a program and as the program executes it keeps track of progress and control decisions. The team leader or manager tells the program who is to do what. The program then automatically releases the work on the appropriate work station. The system can help the manager prepare status reports. Process management programs are only in the preliminary stages of development. Some prototypes are available. CEPA which is designed for Cleanroom is an advanced example of this class of program. CEPA is discussed in section 2.2. CEPA will be used to support the MBC project.

Dispatching decisions are made by the Software Engineering Manager, team leaders and engineers. Which dispatching decisions are to made are summarized in the tasks defined in the process. Software Engineering Managers assign processes to team leaders. Team leaders assign activities to team members.

2.1 A Forms Driven Process Management System

The elements of the form driven system are:

A set of Project Process Management Forms that define the process and the current status of the process for the project. A master set of these forms for the generic process model defined in Volume 1 are included in section 5.

A dispatching form used by the Software Engineering Manager and Team Leaders to issue dispatching systems. The Project Process Management Forms have been designed to serve also as the dispatching form.

A set of project management files located in the state data repository. These files contain soft copies of all Project Process Management Forms.

Software Master Plan showing the activities down to the planning level work break down structure (Figure 3.3 in Volume 1). This plan is used to support the person making a dispatching decision.

A notebook that contains the current Process Management Forms and Software Master Plan. The notebook is used to support Project Process Management Meetings. Each team member has a copy so he or she can understand the project status. In what follows we assume the notebook color is green and we refer to the Project Process Management meeting as the Green book meeting.

Green book meetings. Frequently the staff will meet to review the status of the process. The notebooks will be used to run these meetings. The actual frequency will be based on the needs of the project. It would be rare that a weekly meeting would not be beneficial. A typical agenda for a green book meeting is:

- Review Upcoming Project Calendar
- Specification Process Status and Prospects - Specification Team Leader
- Development Process Status and Prospects - Development Team Leader
- Certification Process Status and Prospects - Certification Team Leader
- Project Status and Prospects - Software Engineering Manager
- Review Action Items
- Assign Action Items
- Dispatching Assignments
- Other Items

There are two aspects that must be defined in how to use the Project Process Management Forms to manage the project using the process. The system must be initialized for a new project and the system must be executed during the course of the project. The steps that must be performed are:

Establishing A New Project

1. Copy the Master Process Management Forms to a file of Project Process Management Forms for the project.

2. Use the facilities of the word processor to do at least the following:
   - specialize the process for the project,
   - update the forms to include the project name and the spiral identification,
   - include multiple copies of forms related to process P4 for each planned specification cycle and P5 and P6 for each planned increment, and
   - complete forms related to process P4 and P5 to a one page reference to help track the multiple copies of Process Management Forms created for these processes.

3. Incorporate project plan dates and other related dates on to the Project Process Management Forms.

4. Print out the forms and file them in the Project Process Management Notebook. It is a good practice to select a notebook color for the project, say green. Then the notebook can be referred to as the green book and project meetings to control the process can be referred to as green book meetings.

5. Establish a frequency and a typical agendas for project process management meetings. Meetings should be short. Their purpose is to review the status of the process and the project, define action items - not resolve problems, make announcements and assign responsibilities for processes and tasks. A typical agenda for a Green Book meeting was presented on the previous page.

Executing The Process For A Project

Projects are executed by assigning responsibility for performing a process or an activity to a team or an engineer. The control flow among processes and activities is specified in terms of sequential, alternative, iterative and concurrent operations. Therefore, the next process or activity to be assigned depends on the realizations of prior processes and/or activities as defined by the control structure.

Process assignments are triggered by the occurrence of a project event. Project events occur whenever a team or person that is responsible for a process or activity reports that an activity is complete or some result has occurred according to an evaluation some predicate in the control structure that defines the project process. In the Cleanroom environment project events normally occur by the completion of Completion Condition forms. Each time a project event occurs it is necessary for a manager or team leader to make a dispatching decision followed by assignment of responsibility to some team or person for the next activity or process to be invoked. The dispatching decision may also require the suspension of some currently assigned processes and/or activities.

The Project Process Management Forms have been used to help managers, team leaders and engineers manage and control the project according the project process. They can be used as follows:

1. Each time a project event occurs, the status of the project is updated on the Project Process Management Form.

2. The control structure is evaluated and the next process or activity that is to be performed is determined. The person who is responsible for making the dispatching decision and then making the assignment uses his/her knowledge and expertise to reach a decision. The decision is then recorded on the Project Process Management Form by either creating a new form or updating the right line on an existing form.

3. The actual assignment is made by giving the person or team leader a copy of the updated or new Project Process Management Form. In actual practice the assignment may be made verbally and the updated or new form is distributed with the next edition of the project green book.

4. Periodically a complete set of the then active Project Process Management Forms are distributed to all project participants. This distribution is made just before or just after a green book meeting.

5. Green book meeting are held periodically, say weekly. At these meetings the Project Process Management Forms are reviewed. In this way the responsible persons can access progress and potential problems and take timely action as required.

2.2 CEPA: An Automated Process Management System

The Cleanroom Engineering Process Assistant (CEPA) is a prototype Process Management System which has been designed to help organizations utilize the Cleanroom process. CEPA has been developed with support from the DARPA/STARS program and is being made available for use by the MBC project at Picatinny by DARPA. Since CEPA is a prototype it is not yet complete but it is believed to have sufficient functionality to provide significant support to the MBC project.

The mission of CEPA is to enable software development organizations using the Cleanroom process to produce high quality products while increasing productivity. The realization of CEPA is as a software engineering environment (SEE) architecture and a set of computer-aided software engineering (CASE) servers that support the Cleanroom process by managing the work activities and information of Cleanroom.

The CEPA approach is innovative in that CEPA provides a top down approach to automating the Cleanroom process. For process support, one must first define and understand the process, then must support the process. Only after supporting the process is it useful to support process steps,

since the steps, and therefore the tools must fit together and co-exist. The Cleanroom process is defined and understood. CEPA supports the Cleanroom process, and provides a framework for further support of process steps. In other words, tools that will assist an engineer in completing part of the Cleanroom process fit into CEPA, and are made available as needed. In that manner, tools can fit in the manner that makes Cleanroom performance most effective.

The CEPA mission is accomplished by providing on-line assistance to all members of the software engineering team in utilizing the Cleanroom process. The Cleanroom process has been shown to facilitate the development of essentially defect-free programs and to increase the development team's productivity. CEPA facilitates managing and following the Cleanroom process, which allows Cleanroom projects to realize even greater benefits. CEPA will have the following missions in aiding members of the development team to use the Cleanroom process:

1. to reduce the time lost because supporting activities are not properly coordinated. CEPA will significantly improve the probability that all of the pre-requisites, tools, and data that an engineer needs to do a task are available with no wasted time on his or her part.

2. to make it easier for the engineer to follow the Cleanroom process, and thereby obtain all of its benefits.

3. to enforce the Cleanroom process in the most unobtrusive way possible by being user-friendly.

4. to facilitate for all levels of management the ability to plan, schedule and control all project tasks and to insure that the required reviews and verifications take place.

5. to improve collection of all required metrics for providing statistical control of the development process.

6. to update on-line state data, which is the data needed to develop the product, and make it immediately available to all members of the development group.

7. to provide direct, on-line access to standards, tutorials and other aids.

8. to improve formal and informal communication between the members of the project team.

In regards to an automated process management system, the first and fourth points above have meaning. CEPA does handle the dispatching responsibility for the parts of the Cleanroom process that appear within its functionality. That functionality is a significant portion of what appears in the procedural definition of the Cleanroom process found in Volume 1. Since CEPA is still a prototype, the functionality of CEPA is not complete with regards to that process definition. So there are some tasks that will be done manually, which puts them out of the control of CEPA.

In regards to the dispatching functionality available to CEPA, a user can assign tasks to other users or teams, which only appear on the other user's pick list when the task is available to be worked on, ie, all necessary information to work on the task is available. Additionally, CEPA will make files inaccessible for update while a specific task is in review, and will mark completed tasks as such. In this manner, CEPA does keep status, and can return to a user the full status of all tasks that are handled within CEPA during the project. Tasks can be reassigned to individuals if the need arises and individuals can be added to or deleted from a project.

CEPA does not yet provide the team leader or manager with sufficient information to enable them to fully control the project. CEPA does not currently have a mapping of activities to a schedule, that is, task assignments and tasks do not have a notion of time associated to them. Therefore, CEPA cannot consider tasks to be ahead or behind schedule, and cannot inform engineers or managers that a schedule is slipping. Additionally, the portions of the Cleanroom process that are not within the realm of CEPA are not known to CEPA, and therefore cannot be controlled.

For the reasons stated above, it is necessary to use the forms developed for the forms based dispatching system to support project and team management and to record project status. These forms can be used with CEPA in the following manner:

1) All tasks assignments made during the Cleanroom project are made using the dispatching forms.
2) For tasks that are not done using CEPA, the forms based approach is followed completely.
3) For tasks that are completed by using CEPA, forms should be distributed so as to inform the assignee of the relationship of the particular task to the schedule. But instead of requiring the engineer to continually return task status, the team leader or manager can use CEPA to determine the current status of tasks. In the event that CEPA does not provide sufficient information for particular tasks, the paper trail of the forms based approach can be reinstated.

SECTION 3: METRICS COLLECTION

Measurements are required to effectively support the appraisal and/or modification of any engineering process. With Cleanroom, metrics play an important role in appraising both the process and the product of the process. The metrics to be discussed in this section are those that relate to Project Execution, that is, for process appraisal during a project and for status reporting to other stakeholders in the project. Metrics that impact Organization Formation and process improvement efforts are discussed in section 2.5 of Volume 2.

The measurements collected in a Cleanroom project can be classified into 8 categories as listed below. Some of the measures are based on direct observations and others require calculation.

Metrics Based On Observation:

- Effort
- Status
- Schedule
- Library Management
- Correctness History

Metrics Based On Calculation:

- Productivity
- Quality
- Cycle Time

Each of the metrics consist of the following specified measures:

Category	Measure(s) Per Category
Effort	a) Technical staff hours per process/task
Schedule	b) Current and projected schedules
Status	c) Tasks assigned d) Current statuses of tasks assigned

Library Management	e) Numbers of new components f) Sizes (Lines of Code) of new components g) Numbers of modified components h) Size (Lines of Code) of modified components i) Numbers of reused components j) Size (Lines of Code) of reused components k) Test scenarios developed per accumulation l) Size of all components changed after first entry into library, per submission.
Correctness History	m) Software system configuration per test suite n) Execution result per test case execution o) Failure reports p) Engineering change notices
Productivity	q) Effort per lines of code developed
Quality	r) Failures and corrections per thousand lines of code developed s) Projected and actual reliability of software system versions
Cycle Time	t) Projected and actual cycle time for project

The collection of these measures ought to be a normal part of the work products and other management activities produced by the organization. The rate at which each of these measures are gathered will vary according to what is most efficient within the organization.

These measures can be collected as described in the following sections:

Effort

Effort measures need to be collected for each activity. This means that the organization's time accounting system needs to be modified to enable each project participant to allocate time spent to the activities. It is suggested that the codes used to identify the activities in the process definition are used as reference for the measures to be collected. The activities for which metrics should be collected are listed in Figure 3.3 of Volume 1.

The effort metrics should be accumulated for each time period and then reported in the Green book. Any significant variations between the plan and actuals must be discussed in the appropriate status report.

Schedule and Status

These measures are maintained on the Project Process Management Forms. The current information is in the Green book. Historical records are in the soft copies of these forms as maintained in the state data repository.

Library Management

All the design objects are maintained in the state data repository. There are commercial programs such as CCC and CMS that can be used to analyze the boxes and prepare the required measures. It is important that this information be prepared directly from the state data repository to insure its accuracy. These activities can be handled by team leaders when completing status reports.

The state data repository should be analyzed frequently, say monthly, and interim information should be reported in the appropriate status reports.

Correctness History

All of these measures are contained in the certification report for each increment. On-going reports of these measures should be a regular part of the certification team leaders status report.

Productivity, Quality and Cycle Time

Actual and project completion estimates should be developed each month by the Software Engineering Manager and included in the monthly project status report so that all project participants continue to focus on these bottom line measures.

CLEANROOM ENGINEERING PROJECT EXECUTION

SECTION 4: COMPLETION CONDITIONS

In this section, forms that define the Completion Conditions for each of the Cleanroom Engineering tasks have been collected. The forms have been grouped into four sections, one for each team and a fourth section for selected management tasks. These forms are suitable for reproduction so they can be completed by team members following a review. Soft copies are also available so team members can fill them out on line and prepare forms for manual entry. In either case, the forms must be filed for reference.

Completion Condition Forms
for
Specification Team Tasks

Task S4.i.2.1 Information Collection

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all potential sources of information from the problem domain been considered? 1a) Has information been gathered from system users? 1b) Has information been gathered from system managers? 1c) Has information been gathered from application domain experts? 1d) Has information been gathered from other classes of system customers?
	2) Have the planned sources of information been approached and information gathered?
	3) Has insights gained been documented?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.2.2 Assemble Information Required for Reverse Engineering of System

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the systems to be reverse engineered been identified?
	2) Have the boundaries for systems to be analyzed been properly defined?
	3) Have all useful sources of information to support the reverse engineering effort for each system been identified? 3a) Does development information exist? 3b) Is documentation available? 3c) Is program code available? 3d) For manual systems, are SOP's available? 3e) Have customers, users and managers been interviewed?
	4) Has all necessary information been cataloged and where required stored in the state data repository?
	5) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.2.3 Manual System Reverse Engineering
Task S4.i.2.4 Automated System Reverse Engineering
Task S4.i.2.5 Hybrid System Reverse Engineering

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the processes observed or researched been documented?
	2) Have the results of the analysis task been documented?
	3) Has a usage hierarchy of system components been discovered?
	4) Has the top level black box model of each system been discovered?
	5) Is the black box model sufficient for the intended purpose? Do system stakeholders agree that it is accurate?
	6) Have all useful abstractions developed during the analysis been placed in a reuse repository for potential reuse by the development team?
	7) Has a memo defining observed discrepancies been prepared to assist in defining the new system?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.2.6 Develop and Analyze Black Box Model

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all known transactions been described using black boxes?
	2) Have any known transitions been described using black boxes?
	3) Has all known black box behavior been documented in a transaction hierarchy?
	4) Has the behavior of the black box model been analyzed?
	5) Have the results of the analysis been documented? 5a) Is model consistent? 5b) Does transaction closure exist? 5c) Is the model clear?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.2.7 Develop and Analyze Markov Usage Model

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all appropriate classes of users been identified?
	2) Have all usage states been identified?
	3) Has a usage model of the system been defined for each class of user? 3a) Are all transition possibilities identified? 3b) Have all transition probabilities been identified?
	4) Is the model consistent with the Markov property?
	5) If usage analysis was done, have the results been documented?
	6) Has the model been evaluated using Markov calculations?
	7) Is the Markov Model consistent with the Black Box function?
	8) Has the model been reviewed with all appropriate stakeholders? Do they think the model is appropriate for its intended purpose?
	9) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.3.1 Information Collection

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all potential sources of information from the solution domain been considered? 1a) Has information on Organizational Architectures been gathered? 1b) Have reuse libraries been identified and accessed? 1c) Have benchmarking studies of best-in-class processes been performed? 1d) Have similar systems been identified and studied? 1e) Have technical experts been consulted?
	2) Have the planned sources of information been approached and information gathered?
	3) Have insights gained been documented?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.3.2 Browse Reuse Repository To Find Match For Needs
Task S4.i.3.3 Prepare Cost/Benefit Analysis
Task S4.i.3.4 Select Potential Reuse Modules for Integration into System

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have potentially reusable objects been gathered?
	2) Have exact and partial matches, in terms of potentially reusable objects, been noted as such?
	3) Has an analysis for a make/buy decision for each object been done? Are the analyzes documented in trade studies?
	4) Have the make/buy decisions been made for each object?
	5) For partial matches, has the extent of modification been planned for and understood?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.3.5 Determine Black Box Behavior Of Other Solution Domain Objects

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all external objects been listed?
	2) Has the behavior related to the system being developed been clearly understood?
	3) Has the necessary behavior been described using black boxes?
	4) Have all system interfaces with external objects been identified and understood?
	5) Has all analysis been documented?
	6) Do the experts in the system objects agree that the model of the object they understand is correct?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.3.6 Develop prototype software using Cleanroom practices

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Is the prototype objective clearly understood and is its cost justifiable?
	2) Have Cleanroom practices been followed in developing the prototype?
	3) Is the specification for the prototyping effort consistent with the prototyping mission?
	4) Has the design trail for the prototype been preserved?
	5) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.3.7 Conduct and appraise prototype experiment
Task S4.i.3.8 Store prototype components in project reuse repository

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all desired experiments been conducted with the prototype?
	2) Have the results of all prototype experiments been documented?
	3) Has the plan for each prototype experiment been documented?
	4) Has the prototype been appraised in regards to the prototyping effort's mission?
	5) Is the entire design trail for the prototype complete?
	6) Is the certification trail for the prototype complete?
	7) Are the prototype's specifications consistent with the implemented prototype?
	8) Have the experimental results based on using the prototype been appraised in regards to the prototyping effort's mission?
	9) Have the results of the prototype experiment been integrated into the system specification?
	10) Has the entire development trail for the prototype been placed in the state data repository?
	11) Has the specification trail for the prototype been placed in the state data repository?
	12) Has the certification trail for the prototype been placed in the state data repository?
	13) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.1 Record Cycle i Results in Mission Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the Mission Statement present all of the stakeholder's requirements for the software?
	2) Are all statements clearly defied as a requirement, constraint or objective.
	3) Are all requirements clear, consistent and unambiguous?
	4) Is each requirement fully justified with a supporting argument?
	5) Is the Mission Statement consistent with regards to the other volumes of the cycle?
	6) Has the Mission Statement been reviewed by the other members of the specification team?
	7) Have all editors for the Mission Statement returned their comments?
	8) Have all readers for the Mission Statement returned their comments?
	9) Have the external stakeholders had the opportunity to review the Mission Statement? Do they all agree the volume fully and completely defines the mission of the software?
	10) Is the mission a mission for a software system?
	11) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.2 Record Cycle i Results in User's Reference Manual Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the User's Reference Manual present all of the stakeholder's external requirements for the software?
	2) Are users and other stakeholders in the system fully satisfied with the definition of all stimuli and responses?
	3) Are all stimuli and responses software stimuli and responses?
	4) Are all stimuli and responses consistent with the black box function?
	5) Is the Users Reference Manual clearly and well written? Is it written from the perspective of the user of the software? Can a subject matter expert use the software using only the users reference manual?
	6) Is the User's Reference Manual consistent with regards to the other volumes of the cycle?
	7) Has the User's Reference Manual been reviewed by the other members of the specification team?
	8) Have all editors for the User's Reference Manual returned their comments?
	5) Have all readers for the User's Reference Manual returned their comments?
	9) Have the external stakeholders had the opportunity to review the User's Reference Manual? Do they all agree the volume fully and completely defines the mission of the software?
	10) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.3 Record Cycle i Results in Black Box Function Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the Functional (Black Box) Specification present all of the stakeholder's behavioral requirements for the software?
	2) Are black box and users reference manual stimuli and responses completely consistent?
	3) Has the behavior of the black box model been analyzed?
	4) Have the results of the analysis been documented? 4a) Is model consistent? 4b) Does transaction closure exist? 4c) Is the model clear?
	5) Is the Functional (Black Box) Specification consistent with regards to the other volumes of the cycle?
	6) Has the Functional (Black Box) Specification been reviewed by the other members of the specification team?
	7) Have all editors for the Functional (Black Box) Specification returned their comments?
	8) Have all readers for the Functional (Black Box) Specification returned their comments?
	9) Have the external stakeholders had the opportunity to review the Functional (Black Box) Specification? Do they all agree the volume fully and completely defines the mission of the software?
	10) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.4 Record Cycle i Results in Mission Validation Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the Specification Validation prove the consistency between the Mission Statement/User's Reference Manual and the Black Box?
	2) Is the Specification Validation consistent with regards to the other volumes of the cycle?
	3) Has the Specification Validation been reviewed by the other members of the specification team?
	4) Have all editors for the Specification Validation returned their comments?
	5) Have all readers for the Specification Validation returned their comments?
	6) Have the external stakeholders had the opportunity to review the Specification Validation? Do they accept the argument?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.5 Record Cycle i Results in Usage Profile Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the Usage Profile present all of the stakeholder's usage requirements for the software?
	2) Have all appropriate classes of users been identified?
	3) Have all usage states been identified?
	4) Has a usage model of the system been defined for each class of user? 4a) Are all transition possibilities identified? 4b) Have all transition probabilities been identified?
	5) Is the model consistent with the Markov property?
	6) If usage analysis was done, have the results been documented?
	7) Has the model been evaluated using Markov calculations?
	8) Is the Markov Model consistent with the Black Box function?
	9) Has the model been reviewed with all appropriate stakeholders? Do they think the model is appropriate for its intended purpose?
	10) Is the Usage Profile consistent with regards to the other specification volumes of the cycle?
	11) Has the Usage Profile been reviewed by the other members of the specification team?
	12) Have all editors for the Usage Profile returned their comments?
	13) Have all readers for the Usage Profile returned their comments?
	14) Have the external stakeholders had the opportunity to review the Usage Profile? Do they all agree the volume fully and completely defines the mission of the software?

	15) Have all additions to, deletions of, and modifications of project state data been completed?

Task S4.i.4.6 Record Cycle i Results in Construction Plan Volume

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the construction plan provide for user executable increments for every accumulation of increments?
	2) Does the final increment of the construction plan provide the full functionality?
	3) Has the construction plan decomposed the system into increments so as to minimize problems for the development team(s)?
	4) Is the Construction Plan consistent with regards to the other volumes of the cycle?
	5) Has the Construction Plan been reviewed by the other members of the specification team?
	6) Have all editors for the Construction Plan returned their comments?
	7) Have all readers for the Construction Plan returned their comments?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task S5.j.1.1 Tailor specification to increment/accumulation j
Task S5.j.1.2 Tailor Usage Profile to increment/accumulation j

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has a Black Box and Usage Profile been prepared for the increment from the parent volumes according to the construction plan?
	2) Are the tailored volumes complete? Have they been placed in the state data repository?
	3) Does the accumulatuion of tailored Black Box functions poccess tranaction closure?
	4) Have all transition possiblities and probabilities been changed to reflect the expected behavior of the accumulation of increments?
	5) Have all additions to, deletions of, and modifications of project state data been completed?

Task S7.1 Consult with Development and Certification Teams About Specification Issues
Task S7.2 Update Specifications as required
Task S7.3 Increase Understanding of Problem and Solution Domains

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the results of all investigations of problem and solution domain been properly reflected in specification and/or communicated to the project staff?
	2) Have all submitted issues from the Development and Certification teams about the specifications been considered?
	3) Have potential changes been presented to the various teams?
	4) Have all changes to the specifications been validated in terms of consistency with other volumes of the specifications?
	5) Have the specifications been maintained under configuration control? 5a) Have all major issues been used to trigger replanning efforts? 5b) Have small changes, corrections and clarifications been maintained in documents? 5c) Have base line documents been issued as required?
	6) Have all appropriate modifications been approved by the Configuration Control Board?
	7) Have changed volumes been baselined and placed in project state data?
	8) Have all changes been distributed to the proper stakeholders?
	9) Do the updated specifications clearly call out changed portions, new portions, and deleted portions?
	10) Have all additions to, deletions of, and modifications of project state data been completed?

Task S8.1 Prepare all required user documentation

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has the user documentation been made consistent with the full specification?
	2) Have the conventions for user documentation been followed?
	3) Have all customer requirements been satisfied?
	4) Have all editors and reviewers returned their comments? Have the comments been appropriately reflected in the documents?
	5) Were the reviewers selected to be representative of the user population?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task S8.2 Specification team prepare final project releases according to the plan

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the desired conventions for the final releases been followed?
	2) Has the consistency between the final releases and the plan been confirmed?
	3) Have the releases been validated for consistency with the project state data?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Task SC2.1 Increase Understanding of Problem and Solution Domains
Task SC2.2 Update Specifications
Task SC2.3 Publish Change Sheets

Cycle (i):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the results of all investigations of problem and solution domain been properly reflected in specification and/or communicated to the project staff?
	2) Have all submitted issues from the Development and Certification teams about the specifications been considered?
	3) Have potential changes been presented to the various teams?
	4) Have all changes to the specifications been validated in terms of consistency with other volumes of the specifications?
	5) Have the specifications been maintained under configuration control? 5a) Have all major issues been used to trigger replanning efforts? 5b) Have small changes, corrections and clarifications been maintained in documents? 5c) Have base line documents been issued as required?
	6) Have all appropriate modifications been approved by the Configuration Control Board?
	7) Have changed volumes been baselined and placed in project state data?
	8) Have all changes been distributed to the proper stakeholders?
	9) Do the updated specifications clearly call out changed portions, new portions, and deleted portions?
	10) Have all additions to, deletions of, and modifications of project state data been completed?

Completion Condition Forms
for
Development Team Tasks

Task D5.j.3.2.2a Refine and Verify Black Box

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have team reviews been held for the Black Box?
	2) Has the Black Box passed its final review?
	3) Have all project/installation standards for BDL been adhered to, including: a) Using only the four basic structures b) Following language syntax conventions c) Providing function commentary where needed?
	4) Is the item developed consistent with the software development plan?
	5) Has the black box function been clearly defined in terms of stimulus histories, and using an acceptable format?
	6) Has the black box function been verified to its specification (Note: A higher level clear box is a lower level black box's specification)?
	7) Does the black box function process all stimuli values, both valid and invalid?
	8) Are all stimuli and responses identified, clearly labeled with meaningful names, and fully described?
	9) Have sufficient black box analyses been performed? Has black box closure been verified?
	10) Are the black box verification arguments complete, accurate, and clear?
	11) Have all additions to, deletions of, and modifications of project state data been completed?

Task D5.j.3.2.2b Refine and Verify State Box

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have team reviews been held for the State Box?
	2) Has the State Box passed its final review?
	3) Have all project/installation standards for BDL been adhered to, including: a) Using only the four basic structures b) Following language syntax conventions c) Providing function commentary where needed?
	4) Has the state box been verifed to provide equivalent behavior to its black box? Are the state box verification arguments complete, accurate, and clear?
	5) Does the state box function process all stimuli values, both valid and invalid, leaving the state data in a valid state?
	6) Have trade studies been conducted for all state data decisions: a) For elaboration at the selected level in the usage hierarchy? b) Does state data abstraction have the right balance between execution speed, performance and verifiability?
	7) Has transaction closure been obtained for all state boxes?
	8) Are all required state data designed, clearly labeled with meaningful names, and fully described?
	9) Are the design decisions on state data grouping good ones?
	10) Have all state box behaviors been clearly defined in terms of current stimulus and current state?
	11) Have sufficient state box analyses been performed? Has state box closure been verified? Has a state usage analysis been performed?
	14) Have all additions to, deletions of, and modifications of project state data been completed?

Task D5.j.3.2.2c Refine and Verify Clear Box

Increment (j):_____ Project:_____ Team:_____ Date:_____

Completion Condition Question:	Y / N
1) Have team reviews been held for the Clear Box? Has the Clear Box passed its final review?	
2) Have all project/installation standards for BDL been adhered to, including: a) Using only the four basic structures b) Following language syntax conventions c) Providing function commentary where needed?	
3) Has the state box been verifed to provide equivalent behavior to its black box? Are the state box verification arguments complete, accurate, and clear?	
4) Are all interfaces in the usage hierarchy well defined?	
5) Has transaction closure been obtained for the clear box?	
6) Are all procedural constructs in the clear box clearly described?	
7) Are the design decisions on the internal black boxes good ones? Do the internal black boxes define cohesive, independent behaviors? Do the internal black boxes support effective state migration?	
8) Have all clear box behaviors been clearly defined in terms of current stimulus and current state?	
9) Have sufficient clear box analyses been performed? Has clear box closure been verified? Is referential transparency clearly supported in the clear box?	
10) Have all object composition opportunities and common service opportunities been explored?	
11) Has the use of concurrent behaviors in the clear box been exploited? If so, are appropriate concurrency controls in place?	
12) Have all additions to, deletions of, and modifications of project state data been completed?	

Task D5.j.3.2.2d Refine and Verify Clear Box Refinement

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have team reviews been held for the Clear Box?
	2) Has the Clear Box passed its final review?
	3) Have all project/installation standards for BDL been adhered to, including: a) Using only the four basic structures b) Following language syntax conventions c) Providing function commentary where needed?
	4) Is the item developed consistent with the software development plan?
	5) Has the Clear box function been validated to be equivalent to its parent clear box function?
	6) Has the shift to the implementation language been just a translation?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task D5.j.2.5 Increase Understanding of Problem and Solution Domains

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) 1) Have the results of all investigations of problem and solution domain been properly reflected in the design and/or communicated to the project staff?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task D6.j.4 Correct failure, verify correction and prepare ECN

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has each engineering change notice been completed properly?
	2) Have all changes been reflected through out the design hierarchy?
	3) Have all changes been verified and passed teams reviews?
	4) Have all engineering change notices been returned to the certification team?
	5) Have any failures remained unresolved?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task D8.3 Development team prepare final project releases according to the plan

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the desired conventions for the final releases been followed?
	2) Has the consistency between the final releases and the plan been confirmed?
	3) Have the releases been validated for consistency with the project state data?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Completion Condition Forms
for
Certification Team Tasks

Task C5.j.2.1 Prepare Test Plan

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Does the test plan for the increment account for all strata necessary for certification?
	2) Does the test plan for the increment present the number of test scenarios planned to certify the increment?
	3) Does the test plan for the increment present the stopping criteria for the certification effort?
	4) Is the test plan consistent with the usage model?
	5) Is the test plan consistent with resource constraints?
	6) Have all additions to, deletions of, and modifications of project state data been completed?

Task C5.j.2.2 Prepare test scenarios or test case generator for accumulation j
Task C5.j.2.3 Determine expected results for test cases

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Are the test scenarios consistent with the test plan for the accumulation?
	2) Are the test scenarios created directly from the usage model for this accumulation?
	3) Have the proper number of test scenarios been created per stratum?
	4) Are the state transitions for the test scenarios randomly generated?
	5) Have expected results been created for each test scenario?
	6) Have expected results been validated in regards to the specification for the accumulation?
	7) Have expected results been organized with their respective test scenarios in order to make the validation effort efficient?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task C5.j.3.4 Increase Understanding of Problem and Solution Domains

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the results of all investigations of problem and solution domain been properly reflected in specification and/or communicated to the project staff?
	2) Have all additions to, deletions of, and modifications of project state data been completed?

Task C6.j.1 Build Accumulation j

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all components in the increment been registered into the library/placed under configuration control?
	2) Has an attempt to compile and/or link/assemble all components been made?
	3) Is the status of the executable system documented?
	4) Is the accumulation consistent with the Construction Plan?
	5) Do all changes have a corresponding Engineering Change Notice?
	6) Has the necessary version information been collected for certification?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task C6.j.2 Perform Certification Tests for Accumulation j

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the suite of test cases been run?
	2) Have all expected results been compared to actual results?
	3) Has appropriate data for reliability estimation been captured?
	4) Have all failure reports been submitted?
	5) Have all failures been resolved by engineering change notices?
	6) Have the certification team attempted to achieve the certification goals specified in the Test Plan?
	7) Have all test scenarios executed been included in the testing log?
	7) Do all changes have a corresponding Engineering Change Notice?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task C6.j.3 Prepare failure report(s)

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has each failure report been completed properly?
	2) Have all failure reports been submitted?
	3) Have all failures been resolved by engineering change notices?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Task C6.j.6 Prepare Certification Report

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have all test executions been noted in the report?
	2) Have all observed failures been noted in the report?
	3) Have actual reliability estimates been made and compared to the expectations?
	4) Has certification of the software been frozen until failures are resolved?
	5) Has the current status of certification, in terms of tests run, and those remaining to be run, been presented in the report?
	6) Has the report been submitted to all necessary stakeholders?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task C8.4 Certification team prepare final project releases according to the plan

Increment (j):_____ Project:_____ Team:_____ Date:_____

Y / N	Completion Condition Question:
	1) Have the desired conventions for the final releases been followed?
	2) Has the consistency between the final releases and the plan been confirmed?
	3) Have the releases been validated for consistency with the project state data?
	4) Have all additions to, deletions of, and modifications of project state data been completed?

Completion Condition Forms
for
Selected Management Tasks

Task M1.4 Tailor software development plan for project/spiral

Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Is the software development plan complete?
	2) Was the Software Development Plan reviewed by its entire set of stakeholders?
	3) Did the Software Development Plan pass its final review?
	4) Does the Software Development Plan follow the format described in Volume 2 of the Engineering Handbooks?
	5) Has the Software Development Plan been archived in its proper place in the project state data?
	6) Have all questions or issues submitted while developing the Software Development Plan been resolved sufficiently to allow completion of the Software Development Plan?
	7) Has the consistency between the Software Development Plan and the Business Plan been validated?
	8) Is the software development plan consistent with the plan for the project/spiral?
	9) Is the plan for the project/spiral complete?
	4) Have skill development resources for the project/spiral been acquired?
	10) Has the project state data repository been created?
	11) Has the process management system been made available?
	12) Have all necessary metrics been gathered in the creation of the Software Development Plan?
	13) Have engineering tools been acquired for the software engineers?

	14) Has the engineering process for the project been defined?
	15) Have engineering handbooks for the project been made available?
	16) Have communications protocols been organized for the project/spiral?
	17) Have the manual enactment mechanisms for the project been completed?
	18) Have all additions to, deletions of, and modifications of project state data been completed?

Task M1.5 Initialize metrics collection activities

Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Do the metrics defined fulfill the requirements for proper Quality, Productivity and Cycle Time measurements?
	2) Are the metrics defined consistent with the process improvement plan?
	3) Has the determination been made between which measures will be automatically gathered and which will be manually gathered?
	4) Are the support measures in place for automatic metrics gathering?
	5) Have the mechanisms for manually gathering metrics been defined in the SDP?
	6) Does the metrics suite cover the full set of Cleanroom metrics to be gathered for the project?
	7) Have all additions to, deletions of, and modifications of project state data been completed?

Task M3.1.k.1 Prepare Review
Task M3.1.k.2 Conduct Review
Task M3.1.k.3 Issue Directives to Implement Review Findings

Review:_____ Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has state data been available for review preparation?
	2) Has all state data been made available for reviewers?
	3) Has all special review material been prepared consistent with specifed requirements?
	4) Has review material been distributed to the review participants in a timely manner?
	5) Have all directives based on the review been distributed to the proper personnel?
	6) Are directives consistent with the current plan?
	7) Has the responsibility to ensure that directives are completed been delegated?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task M4.i.1.1 Establish Objectives For Cycle i
Task M4.i.1.2 Allocate Time Period To Cycle i
Task M4.i.1.3 Prepare Plan For Cycle i

Cycle:_____ Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Are the objectives for the cycle clearly described?
	2) Are the objectives consistent with previous cycles?
	3) Are the objectives consistent with what has been learned on previous cycles?
	4) Is the time period determined for the cycle consistent with the schedule?
	5) Is the plan consistent with the time period?
	6) Is the plan consistent with the objectives?
	7) Does the plan use the resources allocated for the specification cycle?
	8) Have all additions to, deletions of, and modifications of project state data been completed?

Task M4.i.5.1 Review and Evaluate Cycle i Specifications

Cycle:_____ Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Did all appropriate staff and outside experts participate in the review?
	2) In the review and analysis were the following factors considered? 2a) risk mitigation? 2b) cycle objectives? 2c) identification of what was learned? 2d) is the behavior heading in the right direction? 2e) what else needs to be learned? 2f) incremental delivery?
	3) Have all additions to, deletions of, and modifications of project state data been completed?

Task MCS1.1 Appraise Situation and Plan Investigation
Task MCS1.2 Conduct Investigation
Task MCS1.3 Analyze results
Task MCS1.4 Revise Software Development Plan in Accordance with Decision

Replan No:_____ Project:_____ Manager:_____ Date:_____

Y / N	Completion Condition Question:
	1) Has the problem(s) that caused the review been clearly identified and defined?
	2) Has the plan for the investigation been documented? Is the staff available?
	3) Have all results from analysis been documented?
	4) Has the investigation decision been made?
	5) Has the investigation decision been justified?
	6) Has the investigation decision been documented?
	7) Has the SDP been revised?
	8) Have the completion conditions been completed for the revised SDP?
	9) Have all necessary stakeholders been apprised of the results of the investigation?
	10) Have all process status corrections (designing tasks, etc.) been made consistent with the revisions to be made in the Software Development Plan?
	11) Have all additions to, deletions of, and modifications of project state data been completed?

CLEANROOM ENGINEERING PROJECT EXECUTION

SECTION 5: FILE AND TOOL REFERENCE TABLE

Tables that summarize the files necessary to perform each task have been prepared. The tables also list available tools. This information is preliminary so these tables will be updated from lessons learned. There is one table for each team and a fourth table for selected management tasks.

Tool and File List For Specification Team Tasks

Task	Tool	Update Files	Read Files
S2.1 Resolve questions and issues	TP	Question/Issue form	
S2.5 Archive external information	N/A	NONE	
S4.i.2.1 Develop prototype software using Cleanroom practices	TP	Box Structures Design Trail	
S4.1.2.2 Conduct prototype experiment(s)	A/A	A/A	
S4.i.2.3 Appraise prototype experiment(s)	TP	Analysis Report	
S4.i.2.4 Store prototype components in project reuse repository		NONE	
S4.i.3.1 Understand Problem Domain	TP, A/A	Analysis Report	A/A
S4.i.3.2 Understand Solution Domain	TP, A/A	Analysis Report	A/A
S4.i.3.3 Record Cycle i Results In Mission Volume	TP	Mission	Analysis Reports
S4.i.3.4 Record Cycle i Results In User's Reference Manual Volume	TP	User's Reference Manual	Analysis Reports, Mission
S4.i.3.5 Record Cycle i Results In Black Box Function Volume	TP	Black Box Function	Analysis Reports, Mission, User's Reference Manual
S4.i.3.6 Record Cycle i Results In Mission Validation Volume	TP	Black Box Validation	Analysis Reports, Mission, Black Box Function

Task	Tool	Update Files	Read Files
S4.i.3.7 Record Cycle i Results In Usage Profile Volume	TP	Usage Profile	Analysis Reports, User's Reference Manual, Black Box Function
S4.i.3.8 Record Cycle i Results In Construction Plan Volume	TP	Construction Plan	Analysis Reports, Black Box Function
S5.j.1.1 Tailor Black Box function to increment/accumulation j	TP	Increment Black Box Function	Black Box Function
S5.j.1.2 Tailor Users Reference Manual to increment/accumulation j	TP	Increment User's Reference Manual	User's Reference Manual
S5.j.1.3 Tailor Usage Profile to increment/ accumulation j	TP, CT	Increment Usage Profile	Usage Profile
C5.j.2.1 Prepare test plan	TP	Test Plan	Usage Profile, Black Box Function, Construction Plan
S5.j.1.4, SCS2.1 Increase Understanding of Problem and Solution Domains	TP, A/A	Analysis File	A/A
SCS2.2 Update Specification	TP	Mission, User's Reference Manual, Black Box Function, Black Box Validation, Usage Profile, Construction Plan	

Task	Tool	Update Files	Read Files
SCS2.3 Publish Change Sheets		NONE	Mission, User's Reference Manual, Black Box Function, Black Box Validation, Usage Profile, Construction Plan
S7.1 Consult with Development and Certification Teams About Specification Issues	TP	Analysis Report	
S7.2 Update Specification as required	TP	Mission, User's Reference Manual, Black Box, Mission Validation, Usage Profile, Construction Plan	
S8.1 Prepare all required user documentation	TP		Project State Data
S8.2 Specification team prepare final project releases according to the plan	TP		Specification Team State Data

Tool and File List For Development Team Tasks

Task	Tool	Update Files	Read Files
D2.2 Resolve questions and issues	TP	Question/Issue form	
D2.6 Archive external information	N/A	NONE	
C5.j.2.1 Prepare test plan	TP	Test Plan	Usage Profile, Black Box Function, Construction Plan
D5.j.3.1 Select a box design object from pick list	A/A		
D5.j.3.2.1 Refine, verify and team review design object	TP	1) Black Box Files , 2) State Box Files, 3) Clear Box Files, 4) Clear Box Refinement Files	1) Black Box/Parent Clear Box Files, 2) Black Box Files , 3) State Box Files, 4) Clear Box Files / Clear Box Refinement Files
D5.j.3.2.2 Sign completion conditions	TP	Completion Condition Form	
D5.j.3.2.3 Team Decision (1) Continue refinement of design object, (2) Change some prior design decision which requires pruning of design hierarchy		DECISION POINT	
D5.j.3.3 Update pick list	A/A		
D5.j.3.4 Increase Understanding of Problem and Solution Domains	TP, A/A	Analysis File	A/A

Task	Tool	Update Files	Read Files
D5.j.3.5 Team Decision if one is required (1) Increment complete, verified and ready for certification, (2) Design problems-project/spiral should be replanned or (3) Specification problems-specifications should be revised		DECISION POINT	
D6.j.4 Correct failure, verify correction and prepare ECN	TP	Engineering Change Notices	Failure Reports
D8.3 Development team prepare final project releases according to the plan	TP		Development Team State Data

Tool and File List For Certification Team Tasks

Task	Tool	Update Files	Read Files
C2.3 Resolve questions and issues	TP	Question/Issue form	
C2.7 Archive external information	N/A	NONE	
C5.j.2.1 Prepare test plan	TP	Test Plan	Usage Profile, Black Box Function, Construction Plan
C5.j.2.2 Specialize usage profile to accumulation j	TP, CT	Accumulation Usage Profiles, Test Fragments File	Test Plan, Black Box Function
C5.j.2.3 Prepare test scenarios or test case generator for accumulation j	CT, TP	Scenarios/Results File	Test Fragments File, Test Plan, Accumulation Usage Profiles
C5.j.2.4 Determine expected results for test cases	TP, A/A	Scenarios/Results File	Black Box Function
C5.j.2.5 Increase Understanding of Problem and Solution Domains	TP, A/A	Analysis File	A/A
C6.j.1 Build Accumulation j	CT	Testing Log	
C6.j.2 Perform Certification Tests for Accumulation j	TP, CT	Testing Log	Scenarios/Results File
C6.j.3 Prepare failure report(s)	TP	Failure Reports	Testing Log

Task	Tool	Update Files	Read Files
C6.j.6 Prepare Certification Report	TP, CT	Certification Report	Testing Log, Failure Reports, Engineering Change Notices
C8.4 Certification team prepare final project releases according to the plan	TP		Certification Team State Data

Tool and File List For Selected Management Tasks

Task	Tool	Update Files	Read Files
M1.1 Allocate and organize initial project staff	A/A	SDP, A/A	SDP, As Required
M1.2 Allocate and organize other project resources	A/A	SDP, A/A	SDP, As Required
M1.3 Agree on project charter	A/A	SDP, A/A	SDP, As Required
M1.4 Tailor software development plan for project/spiral to Project/Spiral Plan	TP, PL	SDP	SDP Template As Required
M1.5 Initialize metrics collection activities	A/A	A/A	SDP, As Required
M1.6, M2.4 Resolve questions and issues	TP	Question/Issue form	
M1.7, M2.8 Archive external information	N/A	NONE	
M3.1.k.1 Prepare Review	A/A		A/A
M3.1.k.2 Conduct Review	A/A	Review Minutes	A/A
M3.1.k.3 Issue Directives to Implement Review Findings	A/A	A/A	A/A
M3.2.t.1 Prepare and Submit Report t	TP	Status Report Form	
M3.2.t.2 Monitor Metrics Collection		NONE	
M3.3 Organize project staff as required	A/A		Project/Spiral Software Development Plan
M4.i.1.1 Establish Objectives For Cycle i	TP	Cycle Plan	Project/Spiral Software Development Plan

Task	Tool	Update Files	Read Files
M4.i.1.2 Allocate Time Period To Cycle i	TP, PL	Cycle Plan	Project/Spiral Software Development Plan
M4.i.1.3 Prepare Plan For Cycle i	TP	Cycle Plan	Project/Spiral Software Development Plan
M4.i.4.1 Review and Evaluate Cycle i specifications	TP		Mission, User's Reference Manual, Black Box Function, Black Box Validation, Usage Profile, Construction Plan
M4.i.4.2 Management Decision (1) Specifications Suitable To Initiate Development or (2) Specification Problems-Replan Project or (3) Continue Specification Effort with cycle i+1	NONE	DECISION POINT	
MCS1.1 Appraise Situation and Plan Investigation	TP, PL	Analysis Report	A/A
MCS1.2 Conduct Investigation	TP	Analysis Report	A/A
MCS1.3 Analyze results	TP	Analysis Report	A/A
MCS1.4 Revise Software Development Plan in Accordance with Decision	TP, PL	Project/Spiral Plan	
MCS2.4 Management Decision (1) OK continue current plan with revised specifications or (2) Revised specifications require replanning		DECISION POINT	

Task	Tool	Update Files	Read Files
M6.j.5 Management Decision (1) Certification Complete-Accumulation Quality Satisfactory, (2) Certification Complete-Quality Not Satisfactory-Replanning Is Required or (3) Certification Should Continue		DECISION POINT	

CLEANROOM ENGINEERING PROJECT EXECUTION

SECTION 6: MASTER PROCESS MANAGEMENT FORMS

Master Project Process Management Forms are included in this section. Their use was discussed in the two previous sections.

Process Control Documents for
Project &project Spiral &spiral Date July 7, 1993

Establishing A New Project

1. Copy the Master Process Management Forms to a file of Project Process Management Forms for the project. Use the facilities of the word processor to:
   - specialize the process for the project,
   - include dates from project plan
   - update the forms to include the project name and the spiral identification,
   - include multiple copies of forms related to process P4 for each planned specification cycle and P5 and P6 for each planned increment, and
   - complete forms related to process P4 and P5 to a one page reference to help track the multiple copies of Process Management Forms created for these processes.

2. Print and file the forms in the Project Process Management Notebook. The notebook will be used by project participants to assist them in managing the project.

Executing The Process For A Project

1. Each time a project event occurs the status of the project is updated on the Project Process Management Form.

2. The control structure is evaluated and the next process or activity that is to be performed is determined. The person who is responsible for making the dispatching decision and then making the assignment uses his/her knowledge and expertise to reach a decision. The decision is then recorded on the Project Process Management Form by either creating a new from or updating the right line on an existing from.

3. The actual assignment is made by giving the person or team leader a copy of the updated or new Project Process Management Form. In actual practice, the assignment may be made verbally and the updated or new from is distributed with the next edition of the project green book.

4. Periodically a complete set of the then active Project Process Management Forms are distributed to all project participants. This distribution is made just before or just after a green book meeting.

5. Green book meeting are held periodically, say weekly. At these meetings, the Project Process Management Forms are reviewed. In this way, the responsible person can appraise progress and potential problems and take timely action as required.

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P0: Cleanroom Process for Spiral s [This process controls one project spiral.] **do** [P0: Cleanroom process for Spiral s] [P1 results in the organization of staff and resources for performing the spiral (project).] **run** P1: Spiral (Project) Invocation; **con** [P2 provides information management services for the project/cycle, where questions and issues, as well as externally received stimuli, are handled and stored.] **run** P2: Information Management; [P3 results in modified or published spiral (project) plans, spiral (project) reviews or the submission of a spiral (project) status report.] **run** P3: Program Management; **do** [P4 results in specifications for the software to produced in this spiral (project).] **run** P4: Specification Preparation; [P5 and P6 result in software certified to be in conformance with its specifications.] **while** project spiral not terminated **and** plan still has more increments to be certified **do** **con** [P5 results in the development of the software for the spiral (project).] **run** P5: Software Development; [P6 results in the certification of the software for the spiral (project).] **run** P6: Software Certification; **run** P7: Specification Configuration Management; **noc**; **od**; **od**; **noc**; [P8 results in the preparation of all of the project deliverables to all of the project stakeholders] **run** P8: Product (Project) Releases; **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P1: Spiral (Project) Invocation [This process results in the organization of the staff and resources required to perform the spiral (project).] **do** [P1: Spiral (Project) Invocation] **con** M1.1: Allocate and organize initial project staff; M1.2: Allocate and organize other project resources; M1.3: Agree on project charter; M1.4: Tailor software development plan for project/spiral to Project/Spiral Plan; M1.5: Initialize metrics collection activities; M1.6: Resolve all questions and issues; M1.7: Archive external information received; **noc**; **until** Completion Conditions achieved for tasks M1.1 through M1.7 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P2: Information Management [This process provides information management services for the project/cycle] **do** [P2: Information Management] **con** [2.1-2.4 address the resolution of questions for each of the teams, while 2.5-2.8 address the transition into state data of externally received information.] S2.1: Resolve questions and issues; D2.2: Resolve questions and issues; C2.3: Resolve questions and issues; M2.4: Resolve questions and issues; S2.5: Archive external information; D2.6: Archive external information; C2.7: Archive external information; M2.8: Archive external information; **noc**; **until** P8 complete **and** all questions and issues resolved **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Review Name <k>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P3.1.k: Initiate Project Review k, k=1,... **do** M3.1.k.1: Prepare Review; M3.1.k.2: Conduct Review; M3.1.k.3: Issue Directives to Implement Review Findings; **until** Completion Conditions achieved for M3.1.k.3 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Status Report <t>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P3.2.t: Initiate Prepare and Submit Status Report t, t=1,... **do** **con** M3.2.t.1: Prepare and Submit Report t; M3.2.t.2: Monitor Metrics Collection; **noc**; **until** Completion Conditions achieved for M3.2.t.1 and M3.2.t.2 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P3: Program Management [This process results in modified or published spiral (project) plans, spiral (project) reviews or the submission of a spiral (project) status report.] **do** [P3: Program Management] **for** each project time slice **do** **con** **if** Review Scheduled or Major Problem? **then** **case** review is **part** (review name 1) **run** P3.1.k: Initiate Project Review k, k=review name 1; **part** (review name 2) **run** P3.1.k: Initiate Project Review k, k=review name 2; [one part needs to be created for each planned review **else** [Major Problem] **run** P3.1.k: Initiate Project Review k, k=Major Problem; **esac**; **fi**; **if** Status Scheduled? **then** **run** P3.2.t: Initiate Prepare and Submit Status Report t, t=1,...; **fi**; **if** project team needs to be enhanced or changed **then** M3.3: Organize project staff as required; **fi**; **noc**; **od**; **until** Completion Conditions for all initiated processes are achieved **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4: Specification Preparation [This process results in specifications for the software to produced in this spiral (project).] [P4: Specification Preparation] **while** (project spiral not terminated **and** plan still has more cycles to be completed) **or not** (M4.i.5.2 management decision was specification suitable to initiate development) [M4.i.5.2 results in one of the following decisions: Specifications ready, another specification cycle is necessary, stop specifications and replan.] **do** [P4.i handles the investigations for (including prototyping), preparation of, and appraisal of the specifications, resulting in the specifications for a project/spiral when all cycles are complete.] **run** P4.i: Software Specification for Cycle i; [where i is the next cycle in the sequence i= 1...i...m according to the project plan] **if** M4.i.5.2 management decision was specification problems-replan project **or** (this is last cycle in plan **and not** M4.i.5.2 management decision was specifications suitable to initiate development) [M4.i.5.2 results in one of the following decisions: Specifications ready, another specification cycle is necessary, stop specifications and replan.] **then** [PCS1: is a common service procedure which results in an updated Software Development Plan or a decision to terminate current project/spiral.] **run** PCS1: Replan project/spiral; **if** MCS1.4 management decision indicates need to terminate project spiral **then** terminate current spiral **fi**; **fi**; **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i: Software Specification for Cycle i [P4 handles the investigations for (including prototyping), preparation of, and appraisal of the specifications, resulting in the specifications for a project/spiral.] **do** [P4.i: Software Specification for Cycle i] **run** P4.i.1: Prepare Plan for Cycle i; **for** Allocated time period **do** **con** [P4.i.2 studies the problem domain to guide system design] **run** P4.i.2: Problem Domain Analysis-Cycle i; [P4.i.3 studies the solution domain to guide system design including searching for reuse opportunities] **run** P4.i.3: Solution Domain Analysis-Cycle i; [P4.i.4 a complete preparation cycle through the six volume specification] **run** P4.i.4: Prepare Cycle i Specifications; **noc**; **od**; **run** P4.i.5: Appraise Cycle i Specifications; **od**; **corp**;						

Specification Cycle Tracking Form Project &project Date July 7, 1993

Cycle		Responsible	Invoked On	Due On	Completion Date	Status

1	Plan Cycle
	Problem Analysis
	  Information Collection
	  Reverse Engineering
	  Black Box Models
	  Markov Models
	Solution Analysis
	  Information Collection
	  Reuse Analysis
	  Black Box Models
	  Prototyping
	Volume 1
	Volume 2
	Volume 3
	Volume 4
	Volume 5
	Volume 6
	Appraise					

2	Plan Cycle
	Problem Analysis
	  Information Collection
	  Reverse Engineering
	  Black Box Models
	  Markov Models
	Solution Analysis
	  Information Collection
	  Reuse Analysis
	  Black Box Models
	  Prototyping
	Volume 1
	Volume 2
	Volume 3
	Volume 4
	Volume 5
	Volume 6
	Appraise					

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i.1: Prepare Plan for Cycle i **do** [P4.i.1: Prepare Plan for Cycle i] **con** M4.i.1.1: Establish Objectives For Cycle i; M4.i.1.2: Allocate Time Period To Cycle i; M4.i.1.3: Prepare Plan For Cycle i; **noc**; **until** Completion Conditions achieved for M4.i.1.1, M4.i.1.2 and M4.i.1.3 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i.2: Problem Domain Analysis-Cycle i **do** [P4.i.2: Problem Domain Analysis-Cycle i] **con** **for** each analysis method in plan **do** **case** [select the appropriate analysis method] analysis method is **part** Information Collection [collect and document required information] S4.i.2.1: Information Collection; **part** Reverse Engineering [develop black box function for system] S4.i.2.2: Assemble Information for System(s) **for** each system in need of reverse engineering **do** **case** existing system type is **part** Manual S4.i.2.3: Manual System Reverse Engineering; **part** Automated S4.i.2.4: Automated System Reverse Engineering; **part** Hybrid S4.i.2.5: Hybrid System Reverse Engineering; **esac**; **od**; **part** Black Box Models [develop black box function model for system to be built, document in Specification volumes 2 and 3] S4.i.2.6: Develop and Analyze Black Box Model; **part** Markov Usage Models [develop Markov usage model for system to be built, document in Specification volume 5] S4.i.2.7: Develop and Analyze Markov Usage Model; **esac**; **od**; **noc**; **until** sufficient completion conditions achieved for all selected analysis methods **and** (time period up **or** sufficient understanding has been obtained) **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i.3: Solution Domain Analysis-Cycle i **do** [P4.i.3: Solution Domain Analysis-Cycle i] **con** **for** each analysis method in plan **do** **case** [select the appropriate analysis method] analysis method is **part** Information Collection [collect and document required information] S4.i.3.1: Information Collection; **part** Reuse Analysis [consider reuse options effect on system behavior] **do** S4.i.3.2: Browse Reuse Repositories To Find Match For Needs; S4.i.3.3: Prepare Cost/Benefit Analysis; S4.i.3.4: Select Potential Reuse Modules for Integration into System; **until** Completion Conditions achieved for combination of S4.i.3.4 **od**; **part** Black Box Models [document unspecified objects as black box functions] S4.i.3.5: Determine Black Box Behavior Of Other Solution Domain Objects; **part** Prototyping [design, develop, conduct and appraise prototype experiments to appraise solution possibilities] **do** S4.i.3.6: Develop prototype software using Cleanroom practices; S4.i.3.7: Conduct and appraise prototype experiment S4.i.3.8: Store prototype components in project reuse repository; **until** Completion Conditions achieved for combination of S4.i.3.7 and S4.i.3.8 **od**; **esac**; **od**; **noc**; **until** sufficient completion conditions achieved for all selected analysis methods **and** (time period up **or** sufficient understanding has been obtained) **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i.4: Prepare Cycle i Specifications **do** [P4.i.4: Prepare Cycle i Specifications] **con** S4.i.4.1: Understand Problem Domain; S4.i.4.2: Understand Solution Domain; S4.i.4.3: Record Cycle i Results In Mission Volume; S4.i.4.4: Record Cycle i Results In User's Reference Manual Volume; S4.i.4.5: Record Cycle i Results In Black Box Function Volume; S4.i.4.6: Record Cycle i Results In Mission Validation Volume; S4.i.4.7: Record Cycle i Results In Usage Profile Volume; S4.i.4.8: Record Cycle i Results In Construction Plan Volume; **noc**; **until** Completion Conditions achieved for S4.i.4.1 through S4.i.4.8 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Cycle <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P4.i.5: Appraise Cycle i Specifications **do** [P4.i.5: Appraise Cycle i Specifications] M4.i.5.1: Review and Evaluate Cycle i specifications; M4.i.5.2: Management Decision: (1) Specifications Suitable To Initiate Development or (2) Specification Problems-Replan Project or (3) Continue Specification Effort with cycle i+1; **until** Completion Conditions achieved for M4.i.5.2 **od;** **corp;**						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5: Software Development [This process results in the development of the software for the spiral (project).] **con** [Several increments will be in various stages of development] **do** [P5: Software Development] [P5.j results in the development of the software (design and code) and certification plan (sampling plan, test scenarios and expected results) for increment j.] **run** P5.j: Software and Certification Development for Increment j; [where j is the next increment in the sequence j=1...j...n according to the project plan] **if** P5.j.3.5 team decision indicates the need for specification revision [P5.j.3.5 results in one of the following decisions: increment complete -ready to be certified, design problems - replan, specification problems - revisions needed] **then** [PCS2 is a common services procedure which results in an updated specification] **run** PCS2: Update Specifications; **fi**; **if** MPCS2.4 management decision is revised specifications require replanning or P5.j.3.5 team decision indicates the need for replanning [MPCS2.4 results in a decision that: revised specs can be used without replanning or revised specs result in need to replan and P5.j.3.5 results in one of the following decisions: increment complete -ready to be certified, design problems - replan, specification problems - revisions needed] **then** [PCS1: is a common service procedure which results in an updated Software Development Plan or a decision to terminate current project/spiral.] **run** PCS1: Replan project/spiral; **if** MCS1.4 management decision indicates need to terminate project spiral **then** terminate current cycle **fi**; **fi**; **od**; **noc**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5.j: Software Development and Certification Preparation [For each P5.j, the specification is tailored, then the software is designed to the code by the Development team (P5.j.3), while the Certification team does the work necessary to prepare for certification of the increment (P5.j.2).] **do** [P5.j: Software and Certification Planning] **run** P5.j.1: Tailor specification to increment/accumulation j; **con** **run** P5.j.2: Prepare for Certification of Accumulation j; **run** P5.j.3: Increment j Development; **noc**; **until** Completion Conditions achieved for P5.j.2 and P5.j.3 or P5.j.3 team decision indicates the need for replanning or specification revisions **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5.j.1: Tailor specification to increment/accumulation j **do** [P5.j.1: Tailor specification to increment/accumulation j] **con** S5.j.1.1: Tailor Black Box function to increment/accumulation j; S5.j.1.2: Tailor Usage Profile to increment/accumulation j; **noc**; **until** Completion Conditions achieved for S5.j.1.1 and S5.j.1.2 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5.j.2: Prepare for Certification of Accumulation j [This process results in test plan and test scenarios for accumulation j] [P5.j.2: Prepare for Certification of Accumulation j] **con** **do** **do** C5.j.2.1: Prepare test plan; **until** Completion Conditions for C5.j.2.1 achieved **od;** **do** **con** C5.j.2.2: Prepare test scenarios or test case generator for accumulation j; C5.j.2.3: Determine expected results for test cases; **noc;** **until** Completion Conditions for C5.j.2.2 and C5.j.2.3 achieved **od;** **od;** C5.j.2.4: Increase Understanding of Problem and Solution Domains; **noc;** **corp;**						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5.j.3: Increment j Development [Process results in verified software for increment.] **do** [P5.j.3: Increment Development] **con** D5.j.3.1: Select a box design object from pick list; [Items appear on individual developers pick list based on (1) completion conditions achieved for parent design object, (2) design object previously assigned to team member making selection and (3) design object is not yet fully refined] D5.j.3.2: **run** P5.j.3.2 Refine and verify box; D5.j.3.3: Update pick list; [To reflect results of D5.j.3.2] D5.j.3.4: Increase Understanding of Problem and Solution Domains; D5.j.3.5: Team Decision if one is required: (1) Increment complete, verified and ready for certification, (2) Design problems-project/spiral should be replanned or (3) Specification problems-specifications should be revised **noc**; **until** D5.j.3.5 team decision indicates increment complete **or** project should be replanned **or** specifications should be revised **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <> Box <> Refinement <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P5.j.3.2: Refine and Verify Box [Process results in a refined and verified box.] **do** [P5.j.3.2: Refine and Verify Box D5.j.3.2.1: Refine, verify and team review design object; **if** team review passes **then** D5.j.3.2.2: Sign completion conditions; **else** D5.j.3.2.3: Team Decision: (1) Continue refinement of design object, (2) Change some prior design decision which requires pruning of design hierarchy; **fi**; **until** Completion Conditions signed by full team or team review concludes that a prior design decision be modified which requires pruning of design hierarchy and updating of pick list **od**; **corp**;						

Box Refinement Tracking Form Project &project Date July 7, 1993

Box Name	Parent Box		Black	State	Clear	Refinement 1	Refinement 2	Refinement 3	Refinement 4	Refinement 5
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								
		Responsible Invoked Status								

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P6: Software Certification [P6 certifies the software and makes the decision as to whether the software should be accepted or rejected.] **con** [Several increments may be in various stages of certification] **do** [P6: Software Certification] **if** Completion Conditions achieved for P5.j and P6.j-1 **then** [P6.j addresses the actual certification of the developed software for an increment, using the software and certification design from P5.j.] **run** P6.j: Software Certification for Increment j; [where j is the next increment in the sequence j=1...j...n according to the project plan] **if** M6.j.5 management decision is certification quality not satisfactory-replanning required [M6.j.5 results in one of the following decisions: certification complete-quality satisfactory, certification complete-quality not satisfactory-Replanning is required, or certification should continue] **then** **run** PCS1: Replan project/spiral; **if** MCS1.4 management decision indicates need to terminate project cycle **then** terminate current cycle **fi**; **fi**; **fi**; **od**; **noc**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Increment <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P6.j: Software Certification for Increment j [P6.j certifies the code, and makes the decision as to whether an increment will be accepted or rejected.] **do** [P6.j: Software Certification for Increment j] C6.j.1: Build Accumulation j; **if** no pre-certification failures **then** **while** certification plan requires more tests **and** sufficient failures have not been observed to make it desirable to terminate testing and wait for corrections **do** C6.j.2: Perform Certification Tests for Accumulation j; **od;** **fi;** **if** at least one failure observed **and** observed failures are considered to be correctable **then** C6.j.3: Prepare failure report(s); D6.j.4: Correct failure, verify correction and prepare ECN; **fi;** M6.j.5: Management Decision: (1) certification complete-accumulation quality satisfactory, (2) certification complete-quality not satisfactory-replanning Is required or (3) certification should continue; **if not** Management Decision is certification should continue **then** C6.j.6: Prepare Certification Report; **fi;** **until** Completion Conditions achieved for C6.j.6 **od;** **corp;**						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P7: Specification Configuration Management [This process results in the specification being kept current with all changes required due to normal project findings.] **do** **con** S7.1 Consult with Development and Certification Teams About Specification Issues; S7.2 Update Specification as required; S7.3: Increase Understanding of Problem and Solution Domains; **noc;** **until** project spiral terminated **and** Completion Conditions for S7.2 achieved **od;** **corp;**						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc P8: Product (Project) Releases [P8 results in the preparation of all of the project deliverables to all of the project stakeholders] **do** [P8. Product (Project) Releases] **con** S8.1: Prepare all required user documentation; S8.2: Specification team prepare final project releases according to the plan; D8.3: Development team prepare final project releases according to the plan; C8.4: Certification team prepare final project releases according to the plan; **noc**; **until** Completion Conditions achieved for S8.1, S8.2, D8.3 and C8.4 **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Replan ID <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc PCS1: Replan project/spiral [This process results in an updated Software Development Plan or a decision to terminate current project/spiral.] **do** MCS1.1 Appraise Situation and Plan Investigation; MCS1.2 Conduct Investigation; MCS1.3 Analyze results; **if** analysis results in decision to continue **then** MCS1.4 Revise Software Development Plan in Accordance with Decision **fi**; **until** Completion Conditions achieved for MCS1.3 and MCS1.4 if the revise plan was taken **od**; **corp**;						

Project &project Spiral &spiral Date July 7, 1993 (New/Changed/Unchanged) (Active/Inactive/Complete)

Spec Update ID <>

Responsible <> Invoked On <> Due On <> Effort: Plan <> ToDate <> ETC <> Focus <>

	Status	Responsible	To Start	Invoked	Due	Comp
proc PCS2: Update Specifications [This process results in an updated specification] **do** [PCS2: Update Specification] **if** Question or Issue or stimulus from outside project or error discovery causes a specification change **then** **do** **con** SCS2.1: Increase Understanding of Problem and Solution Domains; SCS2.2: Update Specification; **noc**; SCS2.3: Publish Change Sheets; MCS2.4: Management Decision: (1) OK continue current plan with revised specifications or (2) Revised specifications require replanning **until** Completion Conditions for MCS2.4 achieved **od**; **fi**; **od**; **corp**;						